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ABSTRACT

This review of the literature discusses 15 studies that have been conducted on the effect of computer-based instruction on the academic achievement of at-risk students in elementary schools in the United States. The at-risk population consists of those students who are in the free- and reduced-school lunch programs, those students who are non-white, those students who are in Title I schools, and those students who have scored in the lowest quartile on academic achievement tests. The studies fall into the categories of mathematics, reading, telecommunications, Integrated Learning Systems, and higher order thinking skills. The study on mathematics was inconclusive. The majority of the six studies on reading were significantly positive. The two telecommunications studies were mixed-one positive for the treatment group and one positive for the control group. The four studies on Integrated Learning Systems mostly showed significant gains. The higher order thinking skills study showed positive significance in one category. (Contains 16 references.) (Author/AEF)

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The Effects of Computer-Based Instruction on the Academic Achievement of At-risk Students

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Abstract

This review of literature discusses fifteen studies that have been done on the effect of computer-based instruction on the academic achievement of at-risk students. The at-risk population consists of those students who are in the free- and reduced- school lunch programs, those students who are non-white, those students who are in Title I school, and those students who have scored in the lowest quartile on academic achievement tests. The studies fall into the categories of mathematics, reading, telecommunications, Integrated Learning Systems, and higher order thinking skills. The study on math was inconclusive, the majority of the six studies on reading were significantly positive, the two telecommunications studies were mixed-one positive for treatment and one positive for the control group, the four studies on Integrated Learning Systems mostly showed significant gains, and the higher order thinking skills study showed positive significance in one category.

Many studies have been done on the use of computers in the educational setting. This paper will focus on using computer-based instruction with at-risk students in elementary schools in the United States. The operational definition for at-risk students will be those students who are in the free and reduced school lunch programs, those students who are non-white, those students who are in Title I schools, and those students who have scored in the lowest quartile on academic achievement tests.

In considering the effect that computers have in education, studies have been done to determine student achievement with computers, student attitudes toward computers and toward school when using computers, rates of learning using computers, and learning retention with computers. This study will examine the effects of computer-based instruction on the academic achievement of at-risk students in elementary schools in the United States. Computer-based instruction will be defined as any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications. This term may refer either to stand-alone computer learning activities or to computer activities which reinforce material introduced and taught by teachers.

Before looking at the studies involving academic achievement, one must get an accurate picture of how computers are distributed in the educational setting, particularly in regard to equity with the at-risk population. In their study, Computers and classrooms: the status of technology in U.S. Schools (Coley, Cradler, and Engel, 1997, p.13-15), the authors state that previous analyses

have shown that schools with a higher percentage of Title I students had a higher availibility of computers per students. However, the trend has changed. Those schools with a high percentage of minority students particularly have a disadvantage in the computer to student ratio. When the newer multimedia computers are considered, schools with less than 20% Title I students have a ratio of about 22 students per computer, whereas schools with 81% or more Title I students have a ratio of about 32 students per computer (p.15). The same trend holds true for access to the Internet (p.19), to CD-ROMs (p.21), and to networks (p. 23). In spite of this however, those same at-risk students report almost daily use of computers in their schools as opposed to a less frequent use by the general student population (p. 30).

This same study (Coley et al., 1997, p.37-38) reviewed several meta-analyses of computer-based education and concluded that students learn more in classes that use technology. This statement leads to a closer scrutiny of exactly what studies have shown to be the effect of some specific computer-based instructional strategies on the academic achievement of the at-risk population being considered. These studies will be grouped into the five curriculum areas that have been addressed, namely mathematics, reading, telecommunications, broad-based curriculum instruction, and higher order thinking skills.

The first area of mathematics includes a study by Henry J. Becker called Effects of Computer Use on Mathematics Achievement: Findings from a Nationwide Field Experiment in grade Five to Eight Classes: Rationale, Study Design, and Aggregate Effect Sizes (1990). This nationwide study included a sample of 96 classes (48 pairs of "computer" and "traditional" classes) taught by 56 teachers in 31 schools from 25 districts in 16 states. Two were in private and 29 in public schools. Minority groups were 20% or more of the enrollment at one-third of the

schools in the study. Five schools were upper-middle class, and the others were a middle and lower class mixture. Only two schools were in very low-income areas. The classes had a range of ability levels which were split into upper, middle, and lower. A variety of nationally standardardized tests were used as the pretest in the first year, but the Stanford Achievement Test (math computation and math applications parts) was used as the posttest in both years and the pretest in the second year. Three researcher-constructed posttests were also used: a curriculum-specific test, a test of fluency in mental mathematics, and a test of estimation skills. The students were randomly assigned to a class, and then classes were randomly assigned as either a "computer" or a "traditional" class. In 75% of the classes, the same teacher taught both classes. In the other classes, teachers were randomly assigned to either class.

A variety of computer set-ups and software was used and students spent a variety of time on the computers, but each met the minimum time set by the study. The total amount of classtime spent on mathematics was the same for each group with small group activities time and drill time being the main things that were adjusted. Problems with adherence to the computer time allotment caused eight of the first year pairs to be dropped from the study. Correlations among the five posttests were calculated. Pretest differences showed that classes were not equally paired, so posttest scores were used to show net student scores. An effect size was calculated for each posttest by computing the difference in mean residuals between the computer and traditional class and dividing that difference by the pooled raw posttest standard deviation for both classes. None of the effect sizes were significant, but the randomization controlled by the researcher had a more positive effect size than those classes whose randomization was manipulated by the school or by the teacher. This study concluded that "the use of computers did not make much difference

for the students' performance on tests of mathematics skill and applications" (Becker, p. 25). Because the standard deviation of effect sizes on a few single class pairs was larger than that likely to be obtained by chance, one of the variables recommended for further study is that of whether computer use better aids students of differing ability levels.

The next group of studies deals with reading, specifically with the use of the Accelerated Reader computer testing of reading practice and with the use of Reading Renaissance, a combination of Accelerated Reader (AR), sustained silent reading, and mini-lessons. In the first study (Mathis, 1996), the question to be answered was, "Does reading practice cause reading growth?" (p.6). This study used a one group pretest/posttest design. The sample consisted of 36 out of 37 sixth grade students from a rural school in central Illinois. The Stanford Achievement was used as both the pretest and the posttest. The pretest was administered at the end of the fifth grade year, the AR program was used during the entire sixth grade year, and the posttest was administered at the end of the sixth grade year. The gain measured was compared to the gain these same students made from their fourth grade year to their fifth grade year. A t test ($p < .05$) for independent samples was done to see if there was a statistically significant change in reading comprehension net gain scores. No significant increase was measured. Some factors that could have affected the outcome were that some students chose books below their levels so the practice was not effective, and students might not have taken the Stanford test seriously because they were done with a 40 minute test in 10 minutes.

Another one group pretest/posttest study that used Accelerated Reader was conducted on at-risk students only (McKnight, 1992). Although its purpose was to improve reading attitudes, one measure of achievement was used. Students were required to achieve at least a B on a test

that required intensive reading. Pretest daily logs were kept, and during-treatment daily logs were kept on time spent on reading. A pre- and post-survey was completed by each student about their reading and tv watching habits. Reading goals were set and then the students assessed why or why not they had met them. A pre-study library checkout assessment was completed and students kept another checkout log during the study. The use of the flexible library checkout time was pre- and post- assessed. Students' observations of their parents reading were pre- and post-surveyed. Pre- and during-study observations were recorded during silent class reading time. The language arts teachers gave five tests during the study that required intensive reading. The students completed a pre- and post-study attitudinal survey about reading.

The population of the study consisted of 17 fifth grade students who attended Chapter I compensatory classes in a large (800 enrollment) elementary school. The instruments were all researcher- or teacher-made. Neither the validities nor the reliabilities were discussed. Students set goals, checked out books, kept reading logs, observed their parents reading, and won incentive points that they could trade in for prizes. No statistical methods were used except tallying of responses to each of the instruments. A pre-test numerical goal was set for each of the expected outcomes. If the number was matched or exceeded, that outcome was accepted as having been met. The reading log outcome, the reading goal outcome, the book checkout outcome, the parent reading outcome, the silent reading outcome, the reading achievement test outcome, and the positive reading attitude outcomes were met. The two outcomes that were not met were the reduction of television viewing time and the choice of reading as at least the second favorite thing to do in spare time. The researcher's evaluation was that students made a degree of progress toward changing their attitude about reading, but that other choices available in students'

lives were more firmly established, and it would take a long time to change their habits.

A third study using Accelerated Reader (Turner, 1993) specifically targeted underachieving sixth, seventh, and eighth graders to improve their reading achievement and to improve their attitudes toward reading. There were six terminal objectives and eight process objectives to be met. Treatments 1, 2, and 3 were to raise the reading comprehension scores on the Comprehensive Test of Basic Skills up to that of the predicted score on the Cognitive Test of Skills of all sixth, seventh, and eighth grade underachievers. Terminal objectives 4, 5, and 6 were to raise these students' attitudes toward reading as measured by the Estes Survey of Reading Attitude. Process Objective 1 was for these students to read at least 10 books. Process Objective 2 was for library circulation to increase 50%. Process Objective 3 was for the underachieving students to become members of the public library. Process Objective 4 stated that students would achieve success on the Accelerated Reader tests that they took on the books that they had read. Process Objective 5 required teachers to have a one-hour sustained silent reading program each week. Process Objective 6 required one new novel to be added to the reading curriculum in grades six through eight. Process Objective 7 required a written, signed contract for students to read outside of school. Process Objective 8 was that the 10 students who had the greatest discrepancy between anticipated and actual achievement read a selection to younger students.

This study used a correlational comparison between anticipated achievement scores and actual achievement scores. The population consisted of those students in Franklin Elementary School in New Jersey in sixth, seventh, and eighth grades who were identified from their CTBS and TCS scores as being underachievers. Students classified as special education students were not considered for this project. The student body was 98% white and English speaking with 17%

of the students on the free- and/or reduced-price lunch/milk. The instruments used, including the CTBS, the TCS, and the Estes Reading Survey, were used to measure the terminal objectives. The Accelerated Reader computer test scores, documented planned activities, and library records were used to assess the Process Objectives. As a result of the interventions, only terminal objective 6 was met, which was to increase positive attitude toward reading for the eighth grade underachievers. However, 38 of the 46 underachievers (82%) improved their reading comprehension achievement with a mean increase of 8.36 NCE points. Further, 52% of them actually met their original anticipated achievement as predicted on the TCS. Since the published correlation between anticipated achievement scores and actual achievement scores using the TCS and CTBS is considered statistically significant at the .20 level, only 10 of the original students identified as underachievers had discrepancies which were considered statistically significant to begin with. Therefore the population chosen for the study did not entirely meet the beginning statistical significance to be categorized as underachievers.

The fourth study dealing with Accelerated Reader (Institute for Academic Excellence, 1996) had a much broader scope and a more rigorous design that the first three. The purpose of the study was to demonstrate the positive impact of the Accelerated Reader (AR) technology-based literacy program on attendance and standardized test scores. The hypothesis is that the Accelerated Reader has no effect on Texas Assessment of Academic Skills (TAAS) scores or attendance in Texas schools. The research design that was used was a correlation study. The Texas weighted scale for placing schools on a socioeconomic continuum was used to compare each of Texas' 2511 AR schools with a peer group of non-AR schools defined by the Texas Education Agency as the 100 schools nearest it on the scale. Six analyses were used to accept or

reject the hypothesis. The population consists of all the 3rd through 8th grades and the 10th grade in Texas. The instruments used were the TAAS state achievement test, the Orshansky socioeconomic status rating, and the Texas Education Agency attendance records.

First, the TAAS scores were analyzed in reading, math, and overall pass rates for each of the grades tested by calculating the Z scores. In most categories, Z scores showed a statistical significance of at least 5% level and often at the 1% level. The effect appears to become significant during the second year's use of AR, at which point it stabilizes. AR appears to be most effective ($p<.005$) in the urban setting and in the lower socioeconomic status schools ($p<.005$). The density of microcomputers per students has no significant effect on the results. The Z value for attendance was 6.60, showing a strong relationship to the use of AR. Since the criteria used to determine whether AR schools scored better than non-AR schools on the TAAS test was merely the number of students receiving passing scores, no range of difference could be detected. This was a correlational study so no causation was proven. However, the length of ownership analysis discounted a possible self-selection bias. The rural/urban bias is discounted because the AR group had 37% of urban school with 38% in all Texas schools. The analysis of number of computers per student showed no technology bias. Since all schools that owned AR were counted in the AR category regardless of how intensively it was implemented, the study was weighted toward the null hypothesis and therefore no bias was in favor of AR. The biggest benefit from the use of AR was observed with socioeconomically disadvantaged children.

Both of the last studies in reading deal with Reading Renaissance in Texas schools. The purpose of the study conducted by Katie Bolen (1998) is to determine whether students who are taught with Reading Renaissance techniques will gain in reading ability. The three hypotheses are:

(1) no significant gain in reading ability would occur between the pre- and post-tests, (2) students from low socioeconomic (SES) backgrounds would gain less in reading ability than the rest of the group, and (3) students reading below grade level would gain less in reading ability than the rest of the students. The study used a one-group pretest/posttest design. The population was a second grade classroom of 38 students in McCamey, Texas. The test that was used as both the pre- and post-test was the STAR Reading test. During the six month period of the treatment, students practiced reading for sixty minutes each day on books within their Zone of Proximal Development and tested their practice with Accelerated Reader quizzes. The teacher also used fifteen-minute mini-lessons in reading. Student gains were measured in instructional reading level, percentile ranking points, and normal curve equivalent points. The first hypothesis was rejected because students achieved gains on all three measurements. The second hypothesis was rejected because the 23 low SES students made larger gains than the other students. The third hypothesis was also rejected because the growth of students reading below grade level at the beginning of the study averaged 1.8 years of instructional reading growth versus 1.1 average for those above. The number of students who could read above second grade ability tripled by the end of the study.

Since the last study in the area of reading (The Institute for Academic Excellence Educational Research Department, 1999) used a criterion referenced passing score on the Texas Assessment of Academic Skills (TAAS) rather than a nationally-normed achievement test, the results assess increase in the number of student who pass minimal critera rather than a gain in their achievement. The purpose of this study was to determine the effect of Reading Renaissance, an Integrated Learning System that uses computers to track reading practice, on the pass rates of students taking the TAAS. The question first addressed the pass rate of students in grades 6

through 8, and later was extended to all students in the Pittsburg Independent School District (ISD). The research was designed as a correlational study with the use of Reading Renaissance being correlated with the TAAS pass rate in each year from the fall of 1991 to 1998. It was also evaluated as a pretest/posttest one group treatment study. For 1991 through 1994, 500 students from Pittsburg Middle School in rural northeastern Texas were chosen as the study population. There were 36% minority, 45% free-or-reduced lunch, 20% mobility rate, and 60% eligibility for Chapter I. In 1994 the study was extended to all 2,100 students in the entire Pittsburg ISD. By 1998, this population had 52.7% economically disadvantaged students. The Stanford Diagnostic Reading Test was used as a pre- and post-test with alternative forms for grade equivalent growth. The Texas Assessment of Academic Skills was used to assess the pass rate.

The study was on-going on classes using the Reading Renaissance program from the fall of 1991 beginning with seventh grade, and then adding eighth grade and sixth grade. In 1994 all grades were added. Gain scores were calculated as years' growth during each academic year. The junior high correlations were simply displayed as percentage of students passing for each grade, but the whole school district had each academically assessed subject broken down by non-economically disadvantaged and economically disadvantaged groupings. No tests of significance were run on these correlations. However, the pass rate of all students went up for all groups over the course of the study. The increase was greatest for the economically disadvantaged group in all categories of achievement. Another noted phenomenon was that the gap between the number of non-economically disadvantaged students passing and the number of economically disadvantaged students passing narrowed dramatically. The preponderance of evidence on the use of the Accelerated Reader/Reading Renaissance integrated learning system is that it had a significantly

positive effect on academic reading achievement, particularly for at-risk students.

The Apple Classroom of Tomorrow program has targeted at-risk students in particular to treat with telecommunications computer technology in order to gain achievement skills. This study (Ross, Smith, Morrison, Erickson, and Kitabchi, 1989) focuses in on the writing aspect of this project. College education majors were recruited as writing tutors using computer resources to communicate with the students. The researchers used a quasi-experimental group comparison method. Participant groups in the research consisted of 120 fifth- and sixth-grade inner-city, all black elementary students and their parents, teachers, and tutors. Control groups were comprised of approximately equal numbers of children attending matched conventional classes at the same school. Instruments used pre-post gains and outcomes on the California Achievement Test, school attendance, and motivation/self-concept measures. Ten volunteer college students from the Master's of Arts in Teaching program at Memphis State University became tutors to fifth and sixth grade students via an electronic bulletin board system (BBS). All were trained in the use of the system. Tutoring assignments were primarily activities designed to develop writing skills with tutors and tutees sending messages back and forth until the tutor was satisfied that the written work met the teacher's criteria. The students also developed a vocabulary data base which the tutors used to develop learning exercises. The ACOT group had higher standardized test performances, but caution was advised due to the complexity of the additional computer interventions that were done at the same time. Several limitations were noted which included the absence of a clear tutoring curriculum, restricted access to the BBS, lack of participation by some ACOT students, and absence of a program-oriented instructional model for teachers. Writing skills were higher on clarity, organization, and grammar for the ACOT students than for the

control group, and they generally had more concise and better organized essays.

The second study using telecommunications examined the the effectiveness of the Buddy System Project on the academic achievement of fourth- and fifth-grade students in a participating Indiana school. The secondary purpose of the study was to examine equity issues in a home/school computer project by examining the Buddy System Project and achievement test scores in relation to such factors as gender, academic aptitude, and socioeconomic status. The design of the research was ex post facto based on archival data on students who had participated in the project and on students who attended the comparison school in the same school district during the years that the test scores were established. The Buddy System Project involved all fourth-grade students at Eastlawn Elementary in the school year 1988-89, and all fourth- and fifth-grade students in the years 1989-92 (a total of 142). The comparison group at Southlawn Elementary was selected because of its similarities to the treatment group with regard to enrollment size, gender balance, socioeconomic status, and mean pretest achievement and aptitude test scores (a total of 147).

The instruments used to measure achievement in this study were the California Achievement Test (CAT) from 1988 through 1990 and the Comprehensive Test of Basic Skills, 4th edition (CTBS/4) from 1990 through 1992. The CAT test was the instrument used as the pretest and posttest for the academic years 1988-89 and 1989-90. The CTBS/4 was the test utilized for the academic years 1990-91 and 1991-92. Because of the change in instruments after 1990, the schools received the 1990 scores in two formats-as CAT scores and as equated CTBS/4 scores. This facilitated longitudinal comparisons of results. The dependent variables were the changes in scale scores from the pretest to the posttest in the areas of total reading, total

language, and total mathematics. The independent variable of interest was participation in the learning activities associated with the Buddy System Project. Classification variables of interest were gender, academic aptitude, socioeconomic status, the year(s) of the project, and the amount of time involved in the study. A repeated measures design was used with the pretest and posttest scores serving as the within factors. The variables of school, gender, academic aptitude, socioeconomic status, and the year(s) of the project were used as between factors. There was found to be significance in mathematics with relation to treatment after one year. Significance was also found in language with relation to treatment after two years. Likewise, there was significance in mathematics with relation to treatment after two years. In all three of these cases, however, the results were in an unexpected direction: while the treatment group had increases in achievement, the students in the comparison group had significantly higher gains in these areas. Significance was found in reading, language, and mathematics according to treatment and academic aptitude after one year and two years. The differences of the pretest and posttest reading scores by school and gender after two years showed significance. Graphs plotting the mean scores revealed that the significance was not related to the treatment but rather to the fact that the comparison males made greater gains than the comparison females in the study. Students classified as having low academic aptitude scored quite differently according to site. Again, it was the comparison group that outperformed the treatment group. This finding should be viewed with caution because the sample sizes were relatively small and the pretest scores for the comparison group showed high variablility. None of the tests showed any significance according to treatment and socioeconomic status. Therefore, the cost involved in this type of one student to one computer ratio can not be justified by academic achievement alone.

Another comprehensive use of computers to impact achievement is that of the Integrated Learning System (ILS). One study by Catherine Alfrangis (Alfrangis, 1990) used the system developed by Education Systems Corporation which was designed to implement established theories of learning. The study investigated whether students using this system would achieve more in reading and math than a control group. Using a pretest/posttest control group design, fourth through sixth grade students at Dunbar Elementary, a kindergarten, fourth-sixth grade elementary school located at an army base, were stratified by sex, minority, and ability levels, and randomly assigned to class assignments. The classes were then randomly assigned to use either the math computer curriculum or reading computer curriculum.

Fieldnotes, correlations with school objectives, teacher inteviews, student and teacher questionnaires, and achievement scores were collected and analyzed. The 90% match with school objectives was good, but little individualization was evident in the individualization aspects of the computer activities. Teachers felt that ESC was a good supplement, but added to their overloaded school day. Students were positive about the lab experiences, but the results of their Comprehensive Test of Basic Skills achievement test were very mixed. A significant difference was found in mathematics for race, with whites performing better than minorities in all categories. Students in the lowest reading quartile made improvement, but the only significant results were for the whites in reading comprehension. One of the limitations is that the placement test for the instructional level of the computer software may not have been accurate, and some students may have been working below their levels. The software may not have branched the students appropriately to maximize their progress through the lessons. Since students in one academic treatment category were used as the control in the other treatment category, skills learned in both

treatments such as test-taking skills might have blurred the distinction between control and treatment groups. The students in the bottom quartile made "greater than might be expected" (Alifrangis, 1990, p. 15) academic gains including the effects of regression to the mean. Computer activities need to be more fully integrated into the curriculum.

The second study that used an Integrated Learning System was done by Thomas A. Brush (1996). The purpose of this study was to determine whether integrating cooperative learning strategies with Integrated Learning Systems-delivered instruction in mathematics produced positive academic and attitudinal gains in students and, if so, to discern if this strategy was more effective for students with high or low academic ability. The study used a quasi-experimental design. The population consisted of the 71 fifth grade students in the elementary school of a small midwestern city. Six students were not considered, so the sample was 65 students. They were 70% Causasian, 25% African-American, and 5% Asian American. Thirty-seven percent of the students were female, and 63% were male. Approximately 43% were eligible for free or reduced lunch. The California Achievement Test was used as both the pre- and post-test instrument for mathematics achievement. The Josten's mathematics curriculum was used as the instructional content delivered by a networked ILS lab with 30 computer stations in the lab. A student exit questionnaire developed by the researcher was administered to the participating students during the last week of the study. Students completed the pre-test in the third week of school with those scoring below the median classified as "low-achieving" and those scoring above the median as "high-achieving." One class was randomly assigned as the individual learning (control) group. In the other two experimental groups, students were randomly paired and given cooperative learning training. During the time that all groups were working, the researcher

observed and recorded on a predeveloped form comments, questions, and requests for assistance from the students. All students completed an attitudinal survey and the post-test at the end of the 11 week treatment period. The adjusted post-test means on the achievement test were higher for experimental groups than for the control group to the .05 level of significance. Although the difference between the control low-ability group and the experimental low-ability group showed the greatest disparity, it was not significant ($p=.20$). The experimental group showed a significantly greater positive attitude toward math to the $p<.001$ level. They also showed a significantly greater belief that the computer lab work helped them with their math classwork ($p<.05$) and that the computer lab work helped them with their math homework.

The qualitative analysis revealed that the behaviors in the control group were mainly with the desire to be off-task, but the behaviors in the experimental group dealt mainly with group interaction and explanations of subject matter. This study showed that students who had worked in a group rather than individually on an ILS computer-delivered math instruction performed better on a math achievement test, they demonstrated more positive attitudes toward math, and they stayed more on task during instruction. These results might have been due to peer support for subject mastery, more effective use of teacher assistance (working with two students at a time rather than one), and peer support for on-task behavior. The quasi-experimental nature of this study makes it more potentially affected by teaching styles than a true experimental random assignment. However, the results were significantly positive to support further research on uses of other instructional strategies in ILS labs.

A third ILS study was designed to pilot a PLATO/WICAT computer system to see whether it would improve the reading and math skills of elementary students in Chicago. It was

designed as a pretest/posttest one group study. Coleman Elementary in Chicago's South Side has 900 black students from a low-income housing project. About 75% of the students pretested at below the national norms and all but a few come from single-parent families. An entire class was chosen at each grade level, kindergarten through eighth, including one special reduced-size class for young children and one class for the educable mentally handicapped. A total of 10 classes were selected for the study. The Iowa Test of Basic Skills served both as the pretest and the posttest. Classes received four 30 minute sessions in the computer lab in three curriculum areas of instruction: reading, math, and typing. Exposure to the computer program lasted from four to seven months before the posttest. Only the second through the eighth grades took the posttest. Gain scores were calculated from the pre- and post-tests in reading and math. They were described as "significant" gains, but no statistical method was discussed and only the seventh and eighth grades showed a one year gain. The discussion of adding a second computer lab seem to mean that the results were positive enough to warrant the expense. The field notes indicated positive responses from students and faculty.

The fourth study, West Virginia Story: Achievement gains from a statewide comprehensive instructional technology program (Mann, Shakeshaft, Becker, and Kottkamp, 1999) has the largest scope of all of the ILS studies. Using a correlational design, this study purposed to assess the longitudinal effect of West Virginia's "Basic Skills/Computer Education" program on students' academic achievement. The hypothesis was that Stanford 9 achievement gains would be the greatest in schools with the highest amounts of the model components. The population began with all kindergarten students in the state of West Virginia in the year 1990-91. Each successive year for seven years, that class was followed to the next grade and a new

kindergarten class was added to the study. A stratified sample was used across the state to support generalization at the 95% level of statistical confidence with the fifth grade being the one chosen as being the first cohort with consistent BS/CE experience. The instruments used were the IBM or Jostens Learning basic skills software chosen by the state, student and teacher surveys relating to use of computers and software and to attitudes about their use, teacher professional development survey responses, and the Stanford-9 achievement test. Procedures allowed schools to choose whether they wanted the computers for each year's added grade in the classroom or in a lab. A full 30% of the technology funds were spent on teacher training. Data was obtained and quantified on three components of the BS/CE model: software and computer availability and use, attitudes toward computers, and teacher training and involvement in technology implementation decisions. Gain scores on the Stanford-9 were computed for each student from 1997-1998. About 11% of the total variance (r^2=.11 and adjusted r^2=.094) of the gain score increase of fifth grade students could be attributed to their participation in BS/CE. This was significant to the .001 level. Since about 70% of the variation in test scores related to family background, only 30% remained that schools can influence. This study concluded therefore that participation in BS/CE accounted for one-third of the amount that could be influenced by the school. "The BS/CE is more strongly related to gains for students who have less family and social capital and for students who do less well in school" (p.34). There were no differences in gain scores between white students and black. Students who had access to BS/CE computers in their classrooms did significantly better than those who were taught in lab settings.

The final area of consideration of computer-based instruction with at-risk students was their use in raising higher order thinking skills. A study done by J. Gordon Eisenman, Jr.

considered the effects of the Higher Order Thinking Skills (HOTS) program versus the traditional Chapter I program on fourth and fifth grade students' self-concept, reading achievement, and higher order thinking skills. A pretest-posttest contrast group design was utilized. The population was 950 elementary Chapter I students with the sample being 175 fourth and fifth grade Chapter I eligible students from one school district in northeast Georgia. There were 54 first year HOTS student in fourth grade classrooms, 49 second year HOTS students in fifth grade classrooms, and 37 fifth grade students in the control group. Of the total, 149 were black, 24 were white, 2 were Hispanic, 92 were female, and 83 were male. All participated in the free lunch program. Student self-concept was measured using the Self-Description Questionnaire-1 (SDQ1), reading achievement was measured using the Iowa Test of Basic Skills (ITBS), and higher order thinking skills were measured using the Ross Test of Higher Order Cognitive Processes. The same tests were used as pre- and post-tests. Random observations and interviews were used to collect qualitative data.

After treatment, posttest scores were compared using a two-way analysis of covariance (ANCOVA) on each of the separate tests. The multisite interviews and observations were analyzed using the analytic induction method of qualitative data analysis for triangulation data. The fifth grade students in the HOTS program had significantly higher overall self-concepts. There were no significant differences between experimental and control groups in reading achievement. No significant differences were calculated on abstract relations. However, a significant difference in fifth grade between students in the HOTS program and the control Chapter I group, $p<.05$, was found in sequential synthesis. No statistically significant interactions were found between males and females except in the fifth grade for abstract relations, with the

females having higher scores that males, $p<.05$. The qualitative data was used to analyze why the self-concepts were higher. Two reasons were peer perceptions of regard for working with computers, and the use of techniques such as "controlled floundering" which allowed students to initially fail and then work to a solution. The other findings suggested that higher order thinking skills need at least two years of development to achieve significant differences.

In summary of the studies considered by this paper, the one on mathematics concluded that the use of computers did not make much difference on achievement, but admitted that there were some design flaws and areas for further research. The group of studies on reading were mixed, but the preponderance of evidence was positive that the use of Accelerated Reader and Reading Renaissance affected higher reading achievement. This bears out the writer's seven years of experience with Accelerated Reader in a kindergarten through fifth grade school of 270 students with 65% of them on the free- and reduced- lunch program. The conclusions of the two studies that used telecommunications were in opposition to each other with one finding in favor of computer use and the other finding in favor of the control group. The first two studies using Integrated Learning Systems showed gains using computers but not to the level of statistical significance. The third did not use a test of significance at all. However, the fourth study, which had the largest scope, showed a very significant effect of the use of computers on achievement with at-risk students. In the area of higher order thinking skills, significance was found in one category. In all, the studies showed that gains were made in achievement with computers enough to warrant their expense and to warrant further studies on the specific ways in which they can be best utilized in the educational setting.

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